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Estimation of fish composition and catchability coefficient of gillnet in the Shadegan Wetland

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Abstract: To estimate the fish composition and catchability coefficient of gillnet, a survey was carried out during April 2011 to March 2012 in the Shadegan Wetland, Khuzestan Province, Iran. Samples were collected from five stations viz., Mahshar, Rogbe, Khorosy, Salmane and Atish. Approximately 4300 fish specimens were measured and depletion method was used for the estimation of Catchability coefficients of gillnet. Mean±SD q value for Leslie model in different season was 0.008±0.006 and its maximum and minimum values were 0.001 (summer) and 0.004 (spring), respectively. Mean±SD q value for Delury model in different seasons was 0.0007±0.0001 and its maximum and minimum values were 0.002 (summer) and 0.0007 (winter), respectively. Mean±SD of q value for Leslie model in different stations was 0.008±0.006 and for Delury model in different station was 0.003±0.001. Mean catchability value of Leslie model was higher than that for Delury model. Using Students t-test, no significant differences between the calculated Leslie and Delury models among the different stations (P>0.05) and different seasons were observed (P>0.05). A comparison of catchability values showed that there are no significant differences among different seasons (ANOVA, F=0.32, P>0.05) and among different stations (ANOVA, F=0.29, P>0.05).

Keywords: Catchability, Gillnet, Shadegan Wetland, Iran.

Introduction

Several removal methods, such as Leslie and Delury, have been applied in population studies for over six decades (Cowx 1983; Hilborn & Walters 1992). One of the key assumptions of the removal method is that the probability of capture remains constant throughout the entire sampling period. Catchability has been considered as a complicated parameter for a long time (Arreguin-Sanchez 1996; Quinn & Deriso 1999; Francis et al. 2003). Catchability is the combined result of catch, effort, and abundance (Swain & Sinclair 1994; Addison et al. 2003; Salthaug & Aanes 2003). The model is based on the concept of Leslie and Delury removal or depletion methods which have been widely applied in the fishery research (Burridge et al. 2003; McAllister et al. 2004; Young et al. 2004; Wright et al. 2006).

Catchability coefficients (q) as derived from the relationship between indices of catch per unit of effort (CPUE) and average exploitable biomass are supposed to be positively correlated within dices of technological changes. The commonly used relationship is assumed to be linear and is expressed as: F=qf, where F=instantaneous fishing mortality, f =total annual fishing effort expressed in some standard unit and q=a proportionality constant. This relationship between CPUE and stock biomass is commonly expressed as: CPUE=qB, where CPUE=catch per unit of effort expressed in some standard unit, B=exploitable biomass of fish and q=a

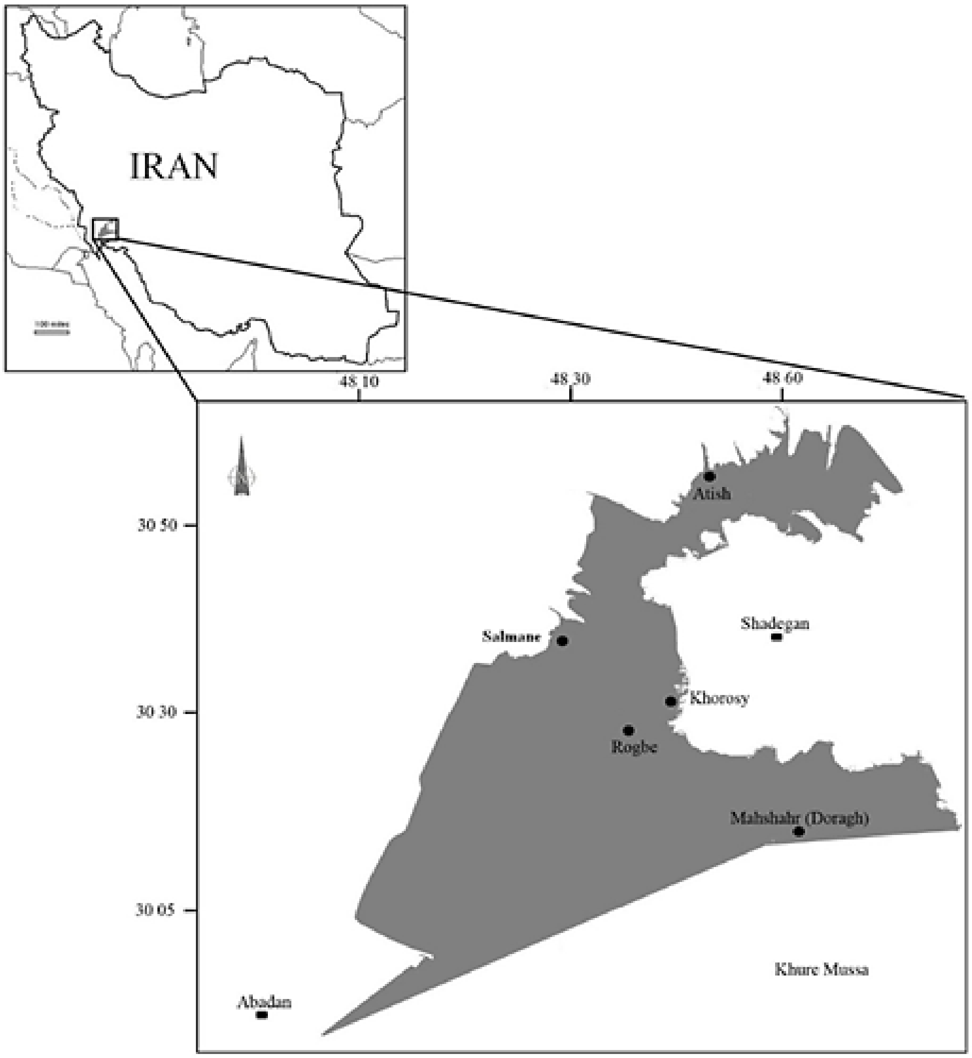

Fig.1. Map of Iran and location of the collection sites in Shadegan Wetland (Khuzestan Province, southwestern Iran).

proportionality constant, referred as catchability coefficient. Catch in a fishery can be expressed in a classical form as (Quinn & Deriso 1999): $C=qE/z\ N0(1-e^{-z})$, Where C denotes catch, q the catchability coefficient, E the fishing effort, z the total instantaneous mortality, and N0 is the initial population size of target species.

Wetlands in the world occupy about 7 to 9 million km^2 of the earth (4-6 percent of Earth surface). Area in Iran's wetlands is approximately 1853762 ha, approximately 25% of Middle East wetlands (Mitsch & Gosselink 2000). The Shadegan Wetland in Khuzestan Province, which is Located 52 km from Abadan and 105 km from Ahvaz, is one of the 18 international wetlands registered on UNESCO's Natural Heritage List. It is also Iran's largest wetland, considered as one of the most interesting natural landscape of the world due to its unique biodiversity, through Jarahi River connected to Persian Gulf waters (Lotfi et al. 2003). In 2006, fish landings in Shadegan Wetland reached a peak of 3700 tons, which corresponds to more than 10 billion$ (Hashemi et al. 2011). Gill net is still the main type of fishing gear used in the fishing areas of the Shadegan Wetland.

In the present study, authors examined the catchability of gillnet diurnally in the Shadegan Wetland with different fish density. Our main aims

Table 1. Mean values and standard deviation (SD) of size corresponding to fish species in the Shadegan Wetland (2011-12), (N= number, M=mean, M(w)= mean weight, M(L)= mean length, Max= maximum, Min=minimum).

Species	N	M(w)±SD (g)	Range	M(L)±SD (mm)	Range
Carasobarbus luteus	104	46±79	266 -18	72±170	257 -95
Cyprinus carpio	836	75±95	1085-80	70±167	399 -18
Liza abu	630	28±34	141 -9	70±140	250 -90
Silurus triostegus	504	36±254	3500 -19	89±295	760 -119
Carassius auratus	455	97±102	568 -9	64±172	322 -24
Mesopotamichthys sharpeyi	417	120±164	651 -15	52±115	374 -115
Aspius vorax	193	117±157	778-37	95±249	405-52
Acanthopagrus arabicus	66	24±48	151-7	63±133	220-80
Alburnoides sp.	42	9±15	29 -7	41±121	165-98
Hypophthalmichthys molitrix	29	14±94	24 -192	120±204	270 -115
Ctenopharyngodon idella	28	145±104	257-37	50±204	270-170
Luciobarbus pectoralis	20	50±123	44-246	33±225	286-166
Ellochelon vaigiensis	17	27±62	133-18	28±169	223 -118
Hypophthalmichthys nobilis	13	21±114	24 -252	22±240	370 -110
Tor grypus	10	25±231	303 -153	54±253	344 -151
Chelon subviridis	6	22±88	110 -48	36±178	223 -191
Thryssa hamiltonii	5	7±19	22 -15	22±144	153 -132
Heteropneustes fossilis	3	28±166	86 -53	70±196	225 -180
Luciobarbus xanthopterus	3	36±146	195 -120	22±214	224 -200
Acanthobrama marmid	2	68±100	160 -25	40±63	150 -11
Sardinella sindensis	2	8±27	31 -23	43±146	155 -138
Mastacembelus mastacembelus	2	28±585	600-570	70±450	465 -435
Cyprinion macrostomum	1	-	-	-	-
Cyprinion kais	1	-	-	-	-
Luciobarbus barbulus	1	-	-	-	-
Tenualosa ilisha	1	-	-	-	-

include estimation of catchability coefficients of gill net as well as different Catchability coefficients in stations and seasons. In the past no study has been made on catchability of gillnet in Khuzestan Coastal Waters (northwest of Persian Gulf), hence, present study is the first one regarding the catchability of gillnet in the Shadegan Wetland based on observation and information analysis. The data presented here can be used to improve fisheries stock management for the native fish species.

Materials and methods

The survey was carried out from April 2011 to March 2012 in the Shadegan Wetland. Samples were collected from five stations, namely Mahshar (48˚,45´E, 30˚, 33´N) Rogbe (48˚,33´E, 30˚,41´N), Khorosy (48˚,40´E, 30˚,39´N), Salmane (48˚,28´E, 30˚,40´N) and Atish (48˚,40´E, 30˚,54´N) in the Shadegan Wetland in Khuzestan Province (Fig. 1). In each season, five stations were selected for sampling. Sampling was carried out by using fixed gill net with 45 mm mesh size (100-120 m length and 50-70 m width) and then transported to the lab on ice. Total length and total weight were measured to the nearest 1 mm and 0.01 g for each fish, respectively. About 800-1500 m^2 (enclosed area) was selected in different seasons and at each station based on environmental conditions. CPUE in each station was estimated for six days.

Catchability is expressed as a unit area (e.g., m^2). In the Leslie method, the relationship between catch per unit effort and population size is defined as: Ct/ft=qB, where t=time period under consideration, q=catchability, B=population biomass. The population at any time t, is equal to the initial population that has been caught up to time t

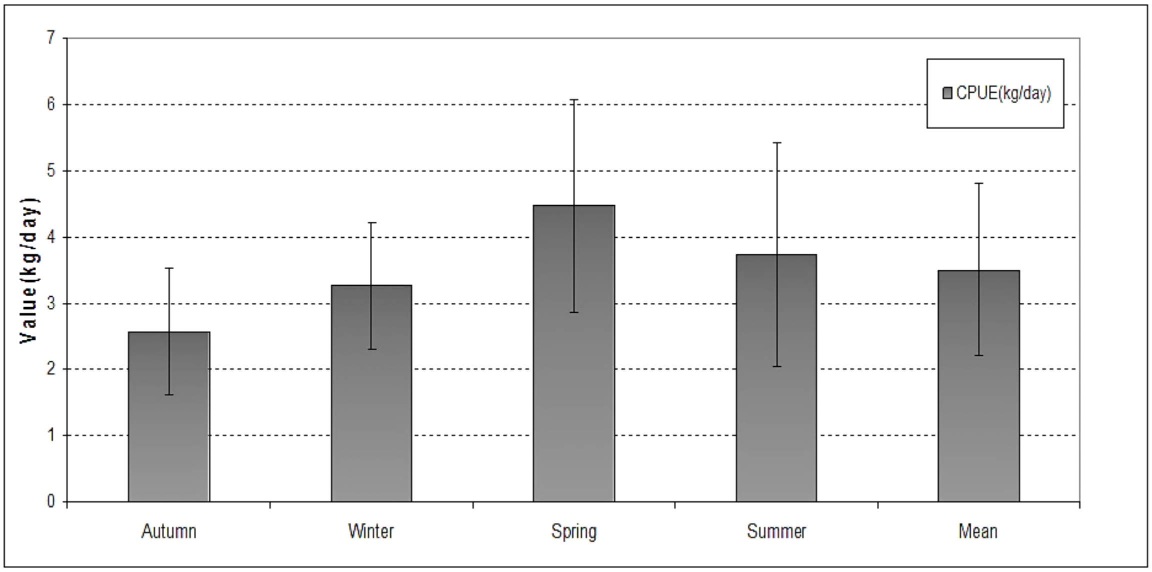

Fig.2. Values of CPUE in different season in the Shadegan Wetland (2011-12).

(cumulative catch), $B_t=B_0-\sum C$; by substituting B_t from the catch per unit relationship into the above expression, a linear relationship is obtained: $Ct/ft=q(B_0-\sum C)$. This relationship implies that if catch per unit is plotted against cumulative catch, a straight line should result in slope equal to catchability and an X intercept equal to the initial population size. The initial population size can therefore be derived from: $B_0=a/q$ (Leslie & Davis 1939). The adjusted cumulative catch (x)—the cumulative catch to interval i plus one half of the catch during interval i proposed by Chapman (1961) compensates for the decline in catchability during each time interval (King 2007).

The daily catch per unit of effort was used as the dependent variable. The generalized Delury method assumes that the relationship between catch per unit effort and population size is of the form: $Ln(Ct/ft)=Ln(qB_0)+Ln(B_t/B_0)$, thus, a plot of Ln (C/f) against cumulative effort up to time period t yields a straight line with slope equal to catchability (q) and intercept equal to In(qB). The initial population size can therefore be derived from: $B_0=e^a/q$ (Delury 1947). A t-test was used for comparison of catchability (q) values in Leslie and Delury models. Comparison of catchability (q) values during season and its temporal variation carried out by analysis of variance (ANOVA). Statistical analyses were performed in SPSS 19 software package at a significance level of 0.05.

Results

During the study, approximately 4300 fish specimens were measured and depletion method was used for Catchability coefficients of gillnet. Among the 26 identified fish species, it was maximum for *Carasobarbus luteus* and minimum for *Cyprinion macrostomum*, *Cyprinion kais*, *Luciobarbus burbulus*, *Tenualosa ilisha*. Mean±SD length values and Mean±SD weight values for these species are shown in Table 1. The mean CPUE (catch per unit effort) for all species was 29 nu/day equivalents to 3.53 kg/day (Fig. 2) and maximum and minimum CPUE values was found to be 4.5±1.61 kg/day (spring) and 2.45±0.94 kg/day (autumn), respectively. The mean depth of fishing was 1m and ranged from 0.5 m to 2.5 m. There was an overall reduction of the catch rate over the 6-day period. This could not be attributed to the changes in fishing method, or current strength, all of which remained constant.

The catchability coefficients (q) of gillnet were calculated in the Shadegan Wetland with Leslie model and Delury model (Table 2). Value q differed

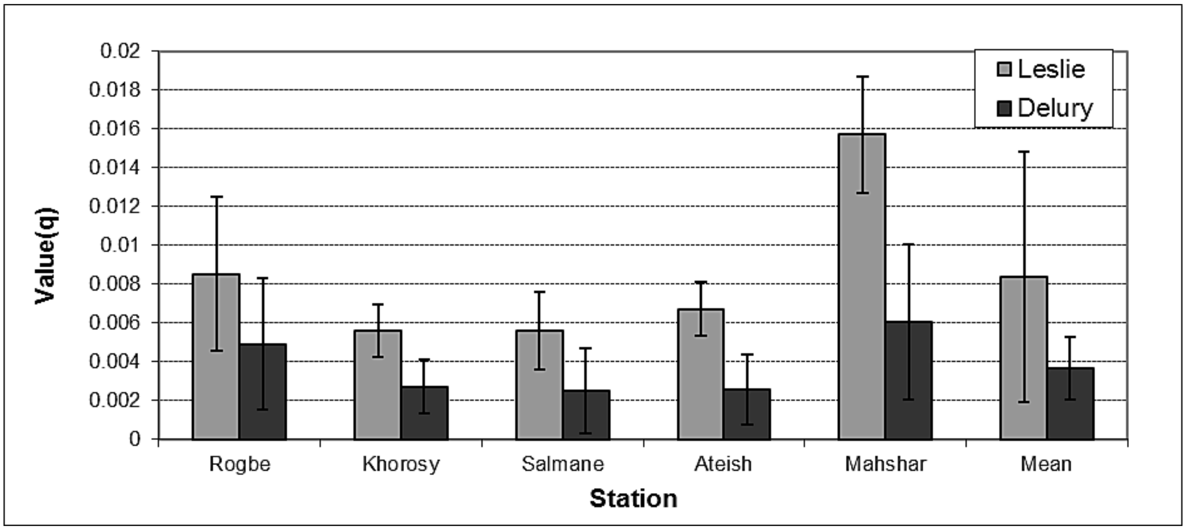

Fig.3. Values of catchability in different station in the Shadegan Wetland (2011-12).

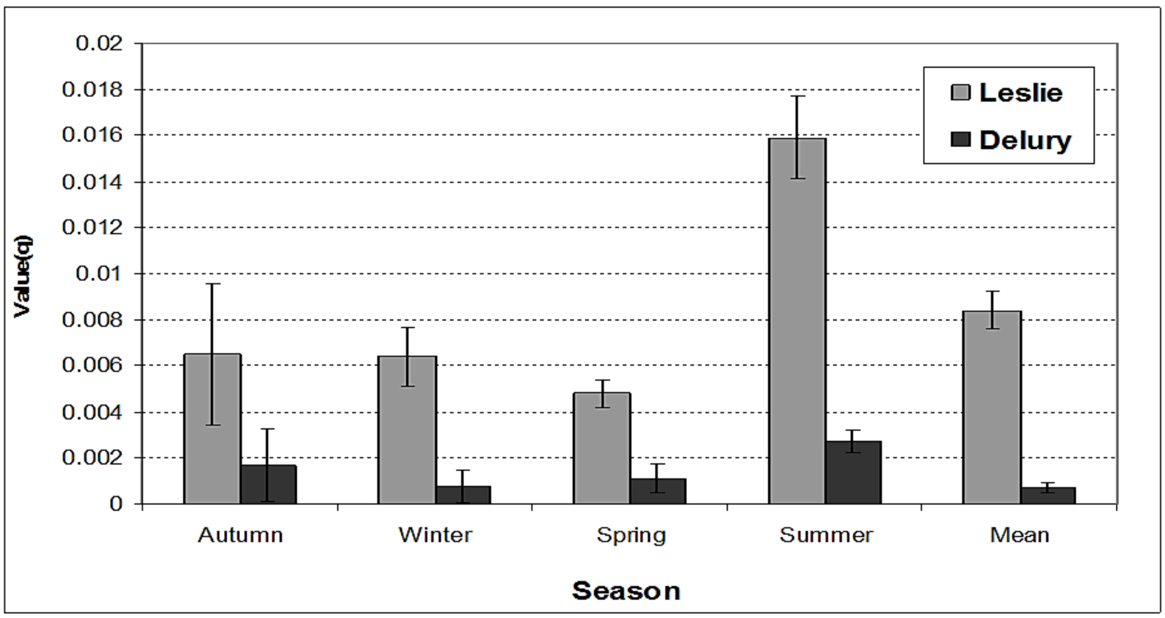

Fig.4. Catchability values in different season in the Shadegan Wetland (2011-12).

in each season and each station in the Shadegan Wetland. Values of catchability in each Station (Fig. 3) and values of catchability in different season are shown in Fig. 4. Mean±SD q values for Leslie model in different seasons was 0.008±0.006 and maximum and minimum q values were 0.001 (summer) and 0.004 (spring), respectively. Mean±SD, q values for Delury model in different season was 0.0007±0.0001 and maximum and minimum q values were 0.002 (summer) and 0.0007 (winter), respectively.

Mean±SD q value for Leslie model in different stations was 0.008±0.006 and for Delury model was 0.003±0.001. Maximum and minimum q values for Leslie model were 0.015 (Mahshar) and 0.006 (Atish) and for Delury model were 0.006 (Mahshar) and 0.002 (Atish), respectively. Average catchability value of Leslie model was higher than Delury model. The Regression Catchability coefficients of gill net in Leslie and Delury models in the Shadegan Wetland are presented in Table 2.

Table 2. The catchability regression coefficients of gillnet for Leslie and Delury models in the Shadegan Wetland (2011-12).

Season	Station	Model	Regression
Autumn	Rogbe	Leslie	Y=-0.0089x+1.95 (r^2=0.75)
		Delury	Y=-0.0052x+0.53 (r^2=0.59)
	Khorosy	Leslie	Y=-0.0076x+1.69 (r^2=0.59)
		Delury	Y=-0.0041x+0.35 (r^2=0.4)
	Salmane	Leslie	Y=-0.0083x+3.10 (r^2=0.68)
		Delury	Y=-0.0052x+1.02 (r^2=0.65)
	Atish	Leslie	Y=-0.0067x+7.10 (r^2=0.68)
		Delury	Y=-0.0014x+1.56 (r^2=0.65)
	Mahshar	Leslie	Y=-0.001x+1.07 (r^2=0.54)
		Delury	Y=-0.003x+0.45 (r^2=0.75)
Winter	Rogbe	Leslie	Y=-0.0058x+1.34 ($r^2$0.46)
		Delury	Y=-0.0013x+0.08 (r^2=0.56)
	Khorosy	Leslie	Y=-0.005x+1.14 (r^2=0.46)
		Delury	Y=-0.0008x+0.10 ($r^2$0.40)
	Salmane	Leslie	Y=-0.0059x+1.48 (r^2=0.42)
		Delury	Y=-0.0014x+0.02 (r^2=0.63)
	Atish	Leslie	Y=-0.0076x+1.77 (r^2=0.4)
		Delury	Y=-0.0014x+1.56 (r^2=0.56)
	Mahshar	Leslie	Y=-0.0081x+1.93 (r^2=0.51)
		Delury	Y=-0.0029x+0.27 (r^2=0.4)
Spring	Rogbe	Leslie	Y=-0.0054x+3.07 (r^2=0.46)
		Delury	Y=-0.0038x+0.98 (r^2=0.4)
	Khorosy	Leslie	Y=-0.0053x+2.02 (r^2=0.56)
		Delury	Y=-0.0028x+0.48 (r^2=0.46)
	Salmane	Leslie	Y=-0.0037x+5.47 (r^2=0.46)
		Delury	Y=-0.0002x+1.44 (r^2=0.47)
	Atish	Leslie	Y=-0.0048x+2.68 (r^2=0.55)
		Delury	Y=-0.0023x+0.76 (r^2=0.57)
	Mahshar	Leslie	Y=-0.0048x+2.92 (r^2=0.5)
		Delury	Y=-0.0033x+0.93 (r^2=0.4)
Summer	Rogbe	Leslie	Y=-0.014x+4.23 (r^2=0.83
		Delury	Y=-0.0094x+1.10 (r^2=0.62)
	Khorosy	Leslie	Y=-0.0045x+2.28 (r^2=0.58)
		Delury	Y=-0.0032x+0.63 (r^2=0.46)
	Salmane	Leslie	Y=-0.0046x+2.70 (r^2=0.73)
		Delury	Y=-0.0032x+0.80 (r^2=0.52)
	Atish	Leslie	Y=-0.0078x+3.09 (r^2=0.73)
		Delury	Y=-0.0052x+0.88 (r^2=0.63)
	Mahshar	Leslie	Y=-0.049x+7.54 (r^2=0.54)
		Delury	Y=-0.015x+1.28 (r^2=0.45)

In general, the Delury equation did not fit the data as well as the Leslie equation had high standard errors. Based on Students t-test, there was no significant difference between values calculated with Leslie and Delury models in different stations ($P>0.05$) and in different seasons ($P>0.05$). There was no significant difference in catchability values in different seasons (ANOVA, $F=0.32$, $P>0.05$) and stations (ANOVA, $F=0.29$, $P>0.05$).

Discussion

The present observations indicate that the level of catchability coefficient differs in each season and each station. The reasons for these differences is probably due to differences in stock biomasses, variations in water qualities, variations in water levels or intimidation of fish outside the gillnet. The relationship between fish communities and the environment has been documented in many cases: fish communities in streams (Brazner et al. 2005), fish communities in wetlands (Brazner 1997) and fish communities in lakes (Tonn & Magnuson 1982). We can calculate the catchability coefficient (q) by using observed catch and effort data. In general, the catchability coefficient varies greatly at low abundance but stabilizes and becomes an approximate constant when abundance increases.

The Khorosy stations during different seasons had high amount of fish biomass (Hashemi et al. 2012) and less catchability coefficient value (inversely in the Mahshar station). It seems that entering the Jarrahi River on eastern side of the wetland and location of Khorosy station near the river month and entry of nutrition element is the probable reason for increasing phytoplankton and phytobenthos production that caused increased fish biomass in these areas. The high diversity of phytoplankton has stabilized the ecological condition in the Khorosy station (Kholfenilsaz 2009). Houghton & Flatman (1980) demonstrated a significant inverse power relationship between catchability coefficient and stock biomass for North Sea cod but not between catchability coefficient and stock numbers. All of these factors can influence the amount of fish caught per unit of effort. Gulland (1964) identified a number of factors contributing to variations in q with time, the major ones, being changes in abundance of the fish being targeted and changes in fleet technology.

The spring season had a high amount of fish biomass (Hashemi et al. 2011) and less catchability coefficient value (inversely in autumn). The reasons for differences in catchability, is probably because of difference stock size, variations in water levels and degradation of water quality which could have great impacts on fish species compositions. The changes in fish communities are often linked to changes in water quality, which have detrimental effects on the fish habitat, such as the loss of vegetation from increased sedimentation and nutrient concentrations (Brouwer et al. 2002) or impairment of fish community in response to an increase in the trophic state of aquatic habitats through nutrient loading (Lee et al. 1991). The tendency of negative power function relationship between q and n0 in this region is consistent with the hypothesis that catchability increases as abundance decreases (Arreguin-Sanchez 1996). Winters & Wheeler (1985) reviewed literature on this subject and pointed out that q has been shown to be inversely related to stock abundance.

The maximum CPUE was obtained in spring (inversely in autumn) and it seems related to wetland climate status (Hashemi et al. 2011, 2012) and nutrients entering to river flow may be due to the season and also maximum phytoplankton production. Wetland phytobenthos appear during spring (Kholfenilsaz 2009). Gillnet CPUE has been used as an index of fish biomass or density in numerous ecological and fisheries studies (Olin et al. 2002; Olin & Malinen 2003). Managers commonly use catch per unit of effort (CPUE) methods for estimating population size and catchability coefficients in fisheries, because these parameters are key parameters in fish exploitation (Zhou et al. 2007).

In contrast, catchability is perhaps the greatest potential source of error in applying the methods of estimation based on secular changes in catch per unit of effort (Ricker 1975). The use of an adjusted cumulative catch is intended to compensate for the decline in catchability during each time interval (Chapman 1961). Nonetheless, as suggested by Cowx (1983), estimates should be treated with care. Because the assumptions of the various fish stock assessment methods usually do not perfectly met, the most reliable stock estimates can be obtained by applying several methods simultaneously. In general, the Delury equation did not fit the data as well as the Leslie equation. Our results showed that the Delury estimates of q become unreliable when q is high and the catches decline to low values during an experiment (also, Seber & Le Cren 1967; Ricker 1975; Loneragan et al. 1995). The assumption that catchability increases steadily over years needs to be closely evaluated for stock assessment purposes. Overestimated catchability in recent years will underestimate stock and exaggerate the fishery impact (Zhou et al. 2008). The most common error in depletion methods is to overestimate catchability and thus to underestimate the initial stock (Hilbom & Walters 1992).

Acknowledgments

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